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ABSTRACT

This set of three modules was designed for use primarily to help teach and reinforce the basic mathematics skills in drafting classes. The modules are based on the needs of drafting students in beginning courses as determined by a survey of teachers across North Carolina. Each module consists of basic information and examples and problem sheets with the solutions on the next page. Also included is a glossary of drafting terms. A set of drafting competencies that require mathematics skills (as determined by a panel of drafting and mathematics teachers) is included. The three modules cover using numbers, scaled measurement, and basic mathematics, scale, and geometry applied to drafting and technical drawing. (KC)

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MATHEMATICS

FOR

DRAFTING

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1985

North Carolina State University

Department of Occupational Education

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To teachers:

This set of modules was designed for use primarily by drafting teachers to help them teach and reinforce the basic math skills in their drafting classes. The modules are based on the needs of drafting students in beginning courses as determined by a survey of teachers from across North Carolina. It is also hoped that mathematics teachers will find the modules useful in reviewing math skills and helping students realize the need for math in the working world.

Please be aware that in some cases exceptions have been made to some basic drafting rules. These exceptions were necessary to provide a clearer explanation of the mathematics concepts involved.

Each module consists of basic information and examples (yellow sheets) and problem sheets with the solutions on the back (green sheets). Also included is a glossary of drafting terms (orange sheets).

The modules have been hole punched to fit in a 3 ring binder so they will be easily accessible. Modules may be given to students as a complete assignment or broken down into smaller parts according to the needs of the students.

A set of drafting competencies which a panel of drafting and mathematics teachers determined to require mathematics skills is included. Through a survey of North Carolina secondary school drafting teachers, the basic mathematics skills required for Drafting I were identified. The three major areas of concern which were identified as basic math, measurement, and geometry were used to develop these modules.

DRAFTING COMPETENCIES NEEDING MATHEMATICS SKILLS

1. Draw orthographic projections.
2. Layout the views for a working drawing.
3. Identify and draw threads.
4. Draw four types of sectional views.
5. Draw an auxilliary view.
6. Draw a pictorial circle.
7. Convert an orthographic angle to a pictorial angle.
8. Draw three types of pictorial drawings.
9. Use proper techniques of geometric construction.
10. Draw floor plans.
11. Dimension floor plans.
12. Draw a foundation plan.
13. Draw a typical wall section.
14. Draw roof types.
15. Draw a plumbing diagram.
16. Draw elevation views.
17. Make an architectural model.
18. Make a cost analysis of a construction project.
19. Describe the principles of construction cost analysis.
20. Demonstrate basic principles of machine drafting.
21. Draw a basic machine shop layout.

MATHEMATICS COMPETENCIES NEEDED IN DRAFTING

1. The learner will demonstrate an understanding of the base ten number system by reading and writing whole numbers through billions.
* 2. The learner will perform the operations of addition, subtraction, multiplication, and division of integers.
* 3. The learner will perform the operations of addition, subtraction, multiplication and division with fractional numbers and/or mixed numbers and express fractions appropriately.
* 4. The learner will perform the operations of addition, subtraction, multiplication, and division with decimal numbers and the changing of decimal numbers to fractions and fractional numbers to decimals.
5. The learner will perform operations with percents such as changing from a percent to a decimal or a percent to a fraction.
6. The learner will locate the graphs of whole numbers, fractional numbers, and integers on the number line.
7. The learner will perform measurement tasks on both straight lines and geometric figures using both English and metric measurements.
8. The learner will interpret information displayed in graphical forms such as bars, circles, broken line graphs, tables, and diagrams.
* 9. The learner will identify geometric figures and parts of figures.
*10. The learner will identify geometric figures, parts of figures, and solve problems related to them.
11. The learner will identify and name the characteristics of sets of points.
*12. The learner will use some of the properties of angles and lines to solve exercises.
*13. The learner will recognize perpendicular and parallel lines and planes and use this knowledge to perform exercises with them.
14. The learner will be able to identify and classify polygons and state their characteristics.
15. The learner will identify congruent triangles.
*16. The learner will solve exercises related to polygons.
17. The learner will identify geometric figures possessing symmetry.
18. The learner will state the characteristics of right angles and solve exercises related to them.
19. The learner will state the characteristics of a circle and solve exercises related to them.
*20. The learner will find the perimeter, area and volume of geometric figures.
21. The learner will compute geometric construction.

*Primary competencies used for development of modules.

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MODULE 1

USING NUMBERS: ADDITION, SUBTRACTION, MULTIPLICATION AND DIVISION

When you began learning mathematics skills, you began with very simple concepts such as:

$1 + 1 = 2$ $\qquad$ $2 \times 2 = 4$

$2 - 1 = 1$ $\qquad$ $4 \div 2 = 2$

and worked up to more difficult concepts including fractions and decimals.

Complete the following worksheets to review your mathematics skills. The problems are designed to give you an idea of how the mathematics concepts may be used by a drafter. You should be able to work most of the problems easily, but if you have forgotten something or need some additional help, tell your teacher.

(Hint: Fractions are written using a / instead of a —. For example, 1/2 means 1 is the numerator and 2 is the demoninator. Mixed numbers are written 1 1/2 with a space between the whole number and the fraction.)

$+$ $\qquad$ $-$ $\qquad$ $\times$ $\qquad$ $\div$

ADDITION

EXAMPLES

$$\begin{array}{r} 733 \\ +\ 179 \\ \hline 912 \end{array}$$

(REMEMBER TO CARRY)

$$1/2 + 3/4 =$$
$$2/4 + 3/4 =$$
$$5/4 = 1\ 1/4$$

(REMEMBER TO REDUCE FRACTIONS)

$$\begin{array}{r} .25 \\ +.50 \\ \hline .75 \end{array} \qquad \begin{array}{r} 11.37 \\ +4.12 \\ \hline 15.49 \end{array}$$

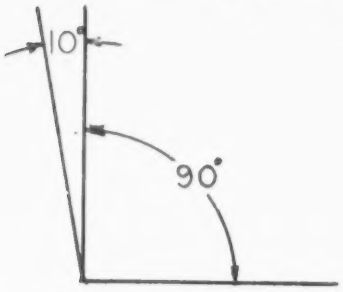
(REMEMBER TO LINE UP DECIMALS)

$$\begin{array}{rcl} 6\ 5/16 & = & 6\ 10/32 \\ +2\ 31/32 & & +2\ 31/32 \\ \hline & & 8\ 41/32 = 9\ 9/32 \end{array}$$

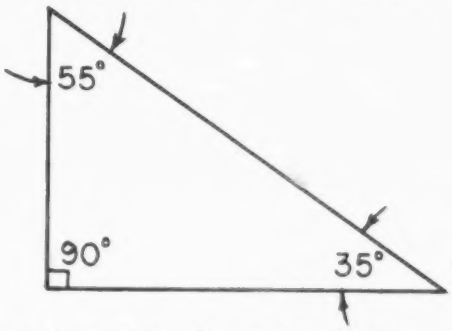
(REMEMBER TO GET COMMON DENOMINATORS AND REDUCE FRACTIONS)

PROBLEMS

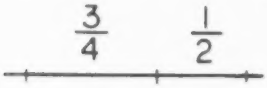
1. a. Suppose you have 2 angles side by side — one is 90^0 and one is 10^0. If you added them together to make one angle, how large would it be?



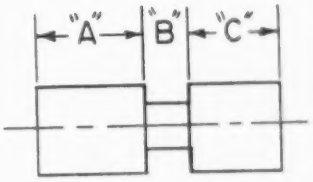
b. A triangle has three angles. One is 90^0, one is 35^0, and one is 55^0. What is the total of the three angles?



2. a. A segment (line) is 3/4 inch long and another segment (line) is 1/2 inch long. If the two are connected, how long would the segment (line) be?



b. A shaft you are to draw has three segments. Segment "A" is 5/8 inch long, segment "B" is 3/16 inch long and segment "C" is 1/2 inch long. To space the drawing correctly on the paper you need to know how long the total shaft is. How long is the shaft?



SOLUTIONS

1a. 90^{o}
$+10^{o}$
100^{o}

b. 90^{o}
35^{o}
55^{o}
180^{o}

2a. 3/4 + 1/2 =
3/4 + 2/4 =
5/4 = 1 1/4 inches

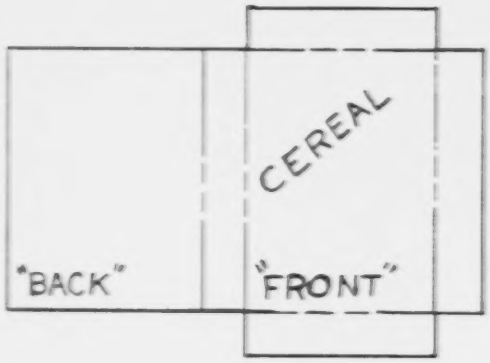
b. 5/8 + 3/16 + 1/2 =
10/16 + 3/16 + 8/16 =
21/16 = 1 5/16 inches

3. You were asked to draw the pattern or stretchout of a cereal box (as if you cut the box open and spread it out). To center the drawing, you need to know how wide the drawing will be at the widest point and how tall it will be at the longest point. You are given the following dimensions:

Front and back – 8 1/2 inches wide x 11 7/16 inches tall
Sides – 2 5/32 inches wide x 11 7/16 inches tall
Bottom and top – 8 1/2 inches wide and 2 5/32 inches tall

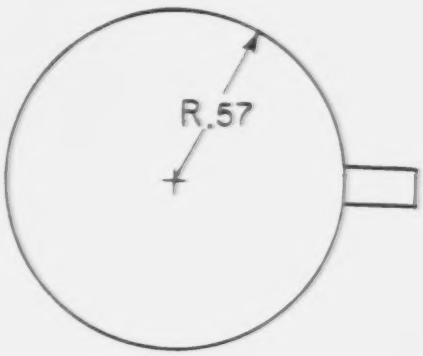
a. How wide will the drawing of the box be (remember to include the front, back, and 2 sides).

b. How tall will the drawing be (remember to include the front and 2 ends)?



4. a. A segment (line) 3.5 inches long is connected to another segment (line) 6.37 inches long. What is the length of the new segment (line)?

b. The radius of the base of a cup you are to draw is .57 inches. If you know that the radius + the radius is equal to the diameter, what is the diameter of the cup base?



3a. 8 1/2 + 8 1/2 + 2 5/32 + 2 5/32 =
8 16/32 + 8 16/32 + 2 5/32 + 2 5/32 =
20 42/32 =
21 10/32 =
21 5/16 inches

or

(8 1/2 + 8 1/2) + (2 5/32 + 2 5/32) =
17 + 4 10/32 =
21 10/32 =
21 5/16 inches

b. 11 7/16 + 2 5/32 + 2 5/32 =
11 14/32 + 2 5/32 + 2 5/32 =
15 24/32 = 15 3/4 inches

or

11 7/16 + (2 5/32 + 2 5/32) =
11 7/16 + 4 10/32 =
11 7/16 + 4 5/16 =
15 12/16 =
15 3/4 inches

4a. 3.50
+6.37
9.87 inches

b. .57
+.57
1.14 inches

MORE PRACTICE

If you had trouble with the above problems, work the following for additional practice:

1. 213
   + 37

2. 147
   32
   8

3. 3/16 + 5/16 =

4. 9 1/4
   + 6 7/32

5. 12 5/32
   + 3/4

6. .25
   + .87

7. 3.87
   + 6.50

8. 4.47
   + 3.03

9. 19/32 + 3/8 =

10. 10 5/8
    + 7 1/2

SOLUTIONS TO "MORE PRACTICE"

1. 240

2. 187

3. 8/16 = 1/2

4. Hint (9 1/4 = 9 8/32)
   15 15/32

5. Hint (3/4 = 24/32)
   12 29/32

6. 1.12

7. 10.37

8. 7.5

9. Hint (3/8 = 12/32)
   31/32

10. Hint (1/2 = 4/8)
    17 9/8 = 18 1/8

SUBTRACTION

EXAMPLES

$$\begin{array}{r} 1684 \\ -\ 795 \\ \hline 889 \end{array}$$

(BORROW WHEN NECESSARY)

$$5/16 - 3/32 =$$
$$10/32 - 3/32 =$$
$$7/32$$

(GET COMMON DENOMINATOR AND REDUCE FRACTIONS)

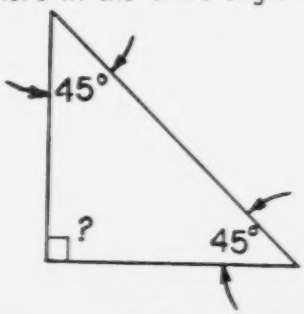
$$\begin{array}{r} 3.87 \\ -\ .50 \\ \hline 3.37 \end{array}$$

$$1\ 1/2 - 1/4 =$$
$$1\ 2/4 - 1/4 =$$
$$1\ 1/4$$

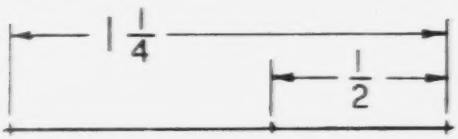
PROBLEMS

1. a. You know that the total length of a drawing is 16 inches. If the object you are drawing is in two segments and you know one of them is 7 inches long, how long is the other segment?

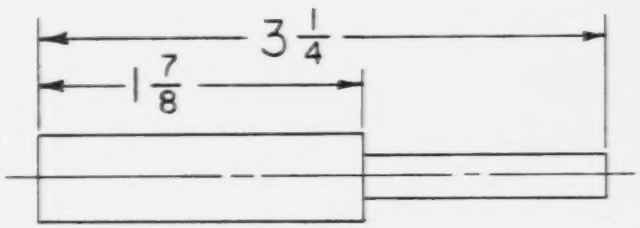
b. All triangles have a total of 180^{0}. If you know that two of the angles have measurements of 45^{0} each, how many degrees are there in the third angle?



2. a. If you have a segment (line) 1 1/4 inches long and you erase 1/2 inch, how long will the remaining (line) segment be?



b. The total dimension of a shaft is 3 1/4 inches. If you know the shaft is divided into two parts and one part is 1 7/8 inches long, how long is the second part?



SOLUTIONS

1. a. $16 - 7 = 9$ inches

b. $45^{o} + 45^{o} = 90^{o}$

$180^{o} - 90^{o} = 90^{o}$

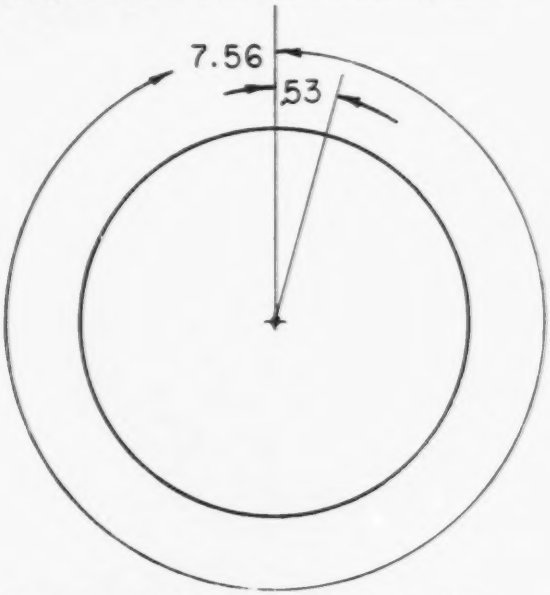
2. a. $1\ 1/4 = 5/4$

$5/4 - 1/2 - 2/4 = 3/4$ inch

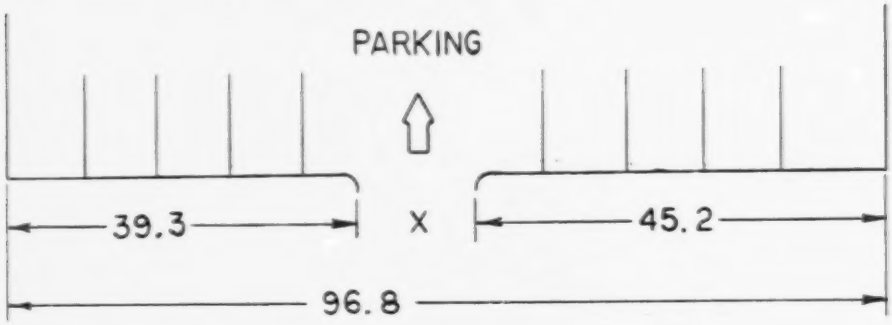
b. $3\ 1/4 = 3\ 2/8 = 2\ 10/8$

$2\ 10/8 - 1\ 7/8 - 1\ 7/8 - 1\ 7/8 = 1\ 3/8$ inches

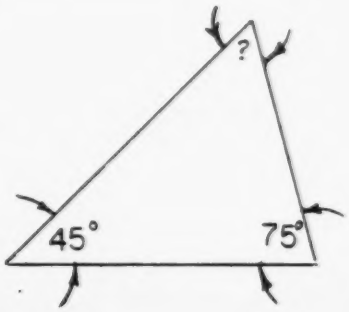
3. a. The circumference of a circle (distance around a circle) is 7.56 inches. An arc (part of a circle) is .53 inch. How many inches are in the remaining arc?



b. A civil engineer was drawing the layout for a new parking lot. He knew the total length of the parking lot was 96.8 feet. A curb was to be poured along one side of the parking lot. One end was 45.2 feet and the other end was 39.3 feet. The remaining space along that side of the parking lot was to be used as an entrance into the parking lot. The specifications said the entrance must be between 10 and 15 feet wide. How wide is the space left for the entrance? Will it meet the specifications?



4. For any triangle, the three angles total 180^0. If you have a triangle with one angle 45^0 and one angle 75^0, what is the other angle?



3. a. $7.56 - .53 = 7.03$ inches

b. $45.2 + 39.3 = 84$

$96.8 - 84.5 = 12.3$ feet

Yes, it will meet specifications

4. $180^{o} = 45^{o} + 75^{o} + x$

$180^{o} = 120^{o} + x$

$180^{o} - 120^{o} = x$

$60^{o} = x$

MORE PRACTICE

If you had trouble with the above problems, work the following for additional practice:

1. $\begin{array}{r} 1784 \\ -\ 895 \\ \hline \end{array}$

2. $\begin{array}{r} 4293 \\ -\ 3554 \\ \hline \end{array}$

3. $1/2 - 9/32 =$

4. $3/4 - 7/16 =$

5. $\begin{array}{r} 11\ 1/4 \\ -\ 9\ 3/32 \\ \hline \end{array}$

6. $\begin{array}{r} 7\ 5/16 \\ -\ 5\ 1/2 \\ \hline \end{array}$

7. $\begin{array}{r} .53 \\ -.25 \\ \hline \end{array}$

8. $\begin{array}{r} .87 \\ -.75 \\ \hline \end{array}$

SOLUTIONS TO "MORE PRACTICE"

1. 889

2. 739

3. $1/2 - 9/32 =$
$16/32 - 9/32 =$
$7/32$

4. $3/4 - 7/16 =$
$12/16 - 7/16 =$
$5/16$

5. $11\ 1/4 = 11\ 8/32$
$\underline{-\ 9\ 3/32} \quad \underline{-\ 9\ 3/32}$
$2\ 5/32$

6. $7\ 5/16 = 7\ 5/16 = 6\ 21/16$
$\underline{-\ 5\ 1/2} \quad \underline{-\ 5\ 8/16} \quad \underline{-5\ 8/16}$
$1\ 13/16$

7. .28

8. .12

9. 5.56
-3.75

10. 12.25
$-\ 3.5$

11. $1/8 - 1/16 =$

12. $1/2 - 7/16 =$

13. 4 15/32
$-\ 1/2$

14. 7 17/32
$-\ 3/4$

15. 5.37
$-\ 2.5$

9. 1.81

10. 8.75

11. 1/16

12. 1/16

13. 3 31/32

14. 6 25/32

15. 2.87

MULTIPLICATION

EXAMPLES

$$\begin{array}{r} 25 \\ \times\ 25 \\ \hline 125 \\ 50 \\ \hline 625 \end{array}$$

3/4 X 1/2 = 3/8

(MULTIPLY NUMERATORS BY EACH OTHER AND DENOMINATORS BY EACH OTHER.)

$$\begin{array}{r} 2\ 1/4 = 9/4 \\ \times\ 1\ 1/2 = 3/2 \end{array}$$

and **9/4 X 3/2 = 27/8= 3 3/8**

$5^2 =$
$5 \times 5 =$
25

(TO SQUARE A NUMBER, MULTIPLY IT BY ITSELF.)

$$\begin{array}{r} 3.75 \\ \times\ 2.5 \\ \hline 1875 \\ 750 \\ \hline 9.375 \end{array}$$

(REMEMBER TO LINE UP DECIMALS. MULTIPLY LIKE WHOLE NUMBERS THEN COUNT THE NUMBER OF DECIMAL PLACES IN THE PROBLEM AND HAVE AN EQUAL NUMBER OF DECIMAL PLACES IN THE ANSWER.)

PROBLEMS

1. Suppose you have a drawing of a table that was drawn to 1/4 size. This means the drawing is 1/4 the size of the actual table. To find the size of the actual table you would multiply each side by 4.

A. 1. Find the actual size of a table drawn 9 inches square.

2. How many sides does a square have?

3. What do you know about the sides of a square?

B. 1. Find the actual size of a rectangular table drawn 3 inches by 6 inches.

2. How many sides does a rectangle have?

3. What do you know about the sides of a rectangle?

2. Suppose you want to draw a table to 3/16 the actual size. To determine the length of each side of the table, you must multiply the actual length of the side times 3/16.

a. What length would each side of a 24 inch square table be?

b. What length would each side of a 12 inch by 36 inch rectangular table be?

SOLUTIONS

1. A. 1. 9
X4
36 inches

2. 4

3. All 4 sides have equal lengths.

B. 1. 3 inches
X4
12 inches

and

6 inches
X4
24 inches

12 inches by 24 inches

2. 4

3. Opposite sides are equal

2. a. 24 X 3/16 =
24/1 X 3/16 =
72/16 =
4 8/16 =
4 1/2

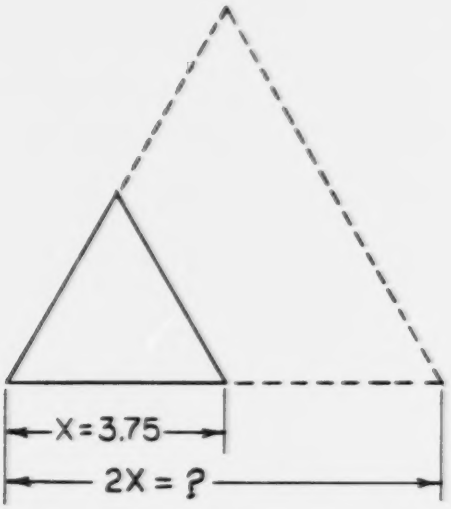
b. 12 inches by 36 inches
12 X 3/16 =
12/1 X 3/16 =
36/16 =
2 4/16 =
2 1/4

and

36 X 3/16 =
36/1 X 3/16 =
108/16 =
6 12/16 =
6 3/4

(THE TABLE WOULD BE DRAWN 2 1/4 INCHES BY 6 3/4 INCHES)

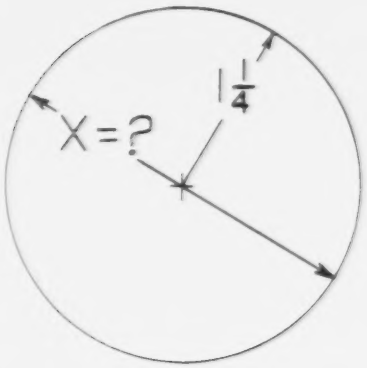
3. Suppose you have an equilateral triangle (a triangle with all sides equal) and each side measures 3.75 inches.



a. If you make each side twice as long, how long would each side be?

b. If you make each side 3 times as long, how long would each side be?

4. If you know the radius of a circle (distance from center of circle to outside edge) is 1 1/4 inches, what is the diameter (distance from edge to edge through center of circle)?

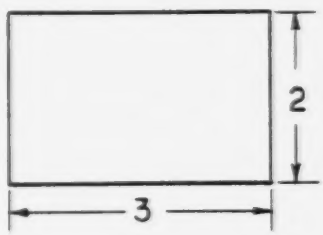


3.a. 3.75 inches
X 2
7.50 inches

b. 3.75 inches
X 3
11.25 inches

4. 1 1/4 X 2 = 2 1/2

5. To find the area of a square or rectangle, we multiply the length of one side by the length of the adjacent side. If you have a rectangle with two sides that are each 3 inches long and two sides that are each 2 inches long, what would be the area of the rectangle?

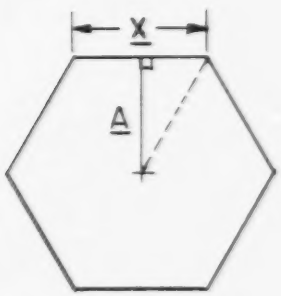


6. To find the area of a regular hexagon we use the formula A= 1/2 x A x P where "A" is the distance from the center of the hexagon to the side, and "P" is the perimeter of the hexagon (or 6X).

a. If you know that A=7, and X=10, what is the area?

b. If you know that A=5 and X=5 1/2, what is the area?

(Hint: P = 6X)



$$A = \frac{1}{2} \times A \times P$$

5. 3 X 2 = 6 inches

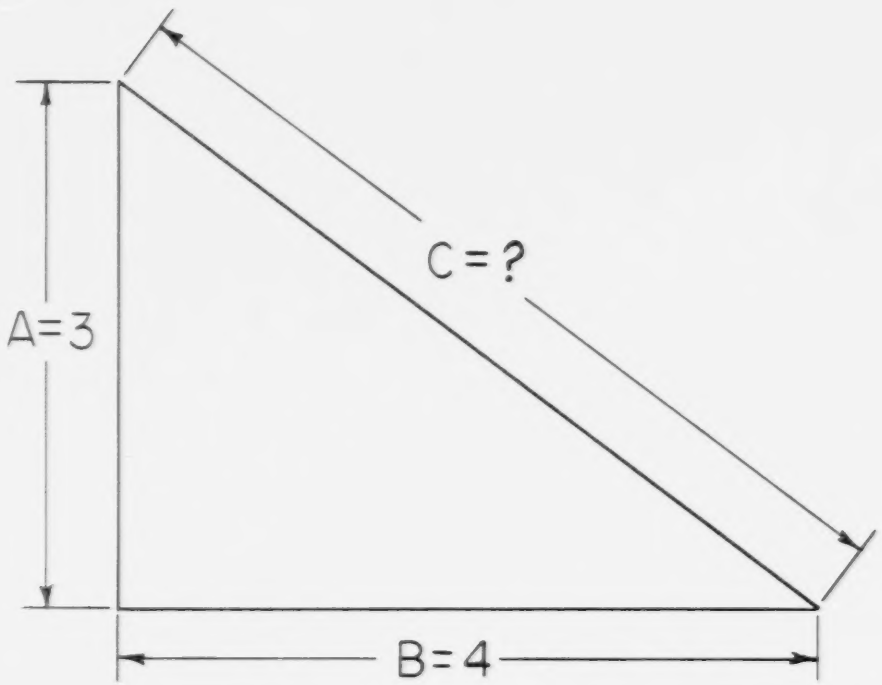
6. A = 1/2 X a X P
   P = 6X
   P =6 X 10
   P = 60

   a. A = 1/2 X 7 X 60 =
      A = 1/2 X 7/1 X 60/1 =
      A = 420/2
      A = 210

   P = 6X
   P = 6 X 5 1/2
   P = 33

   b. A = 1/2 X 5 X 33
      A = 1/2 X 5/1 X 33/1
      A = 165/2
      A = 82.5

7. In a triangle that has a right angle we can determine the length of the longest side (hypotenuse) if we know the length of the other two sides by using the formula $c^2 = a^2 + b^2$ (where c = the longest side). If you know that side "a" = 3 inches and side "b" = 4 inches, what is c^2? (To find "c" use a square root table or a calculator.)



7. $C^2 = a^2 + b^2$

$C^2 = 3^2 + 4^2$

$C^2 = 9 + 16$

$C^2 = 25$ inches

(C WOULD BE 5 SINCE $5^2 = 25$)

$C^2 = 25$

$C = \sqrt{25}$

$C = 5$

MORE PRACTICE

If you had trouble with the above problems, work the following for additional practice.

1. 24
   X 4

2. 75
   X 25

3. 3/8 X 5/16=

4. 7/8 X 9/32 =

5. 4.87
   X .47

6. 11.75
   X 8.5

7. 3 1/8
   X 2 3/4

8. 2 1/2
   X 3 3/4

9. 3/8 X 13/16

10. 9.37
    X 3.06

SOLUTIONS TO "MORE PRACTICE"

1. 24
   X 4
   96

2. 75
   25
   375
   150
   1875

3. 3/8 X 5/16 =
   15/128

4. 7/8 X 9/32 = 63/256

5. 4.87
   X .47
   3409
   1948
   2.2889

6. 11.75
   X 8.5
   5875
   9400
   99.875

7. 3 1/8 =25/8
   X 2 3/4 =11/4

   25/8 X 11/4 =

   275/32 =

   8 19/32

8. 2 1/2 = 5/2
   X 3 3/4 =15/4

   5/2 X 15/4 =

   75/8 =

   9 3/8

9. 3/8 X 13/16 = 39/128

10. 9.37
    X 3.06
    5622
    000
    2811
    28.6722

DIVISION

EXAMPLES

```
    12
16 192
   16
   32
   32
    0
```

1/2 ÷ 1/16 =
1/2 X 16/1 =
16/2 =
8

(REMEMBER: INVERT AND MULTIPLY.)

6 3/16 ÷ 3 5/8 =
99/16 ÷ 29/8 =
99/16 X 8/29 =
792/464 = 99/58 =
1 41/58

(REMEMBER: CHANGE TO IMPROPER FRACTION, INVERT AND MULTIPLY.)

```
      1.48
25  37.00
    25
    120
    100
     200
     200
     000
```

```
      2.5
1.5 3.75 = 15 37.5
          3.0
           75
           75
            0
```

(REMEMBER: MOVE THE DECIMAL OUTSIDE THE DIVISION BAR AND INSIDE THE DIVISION BAR, ADDING 0'S IF NEEDED.)

```
      .4
25  10.0
    100
```

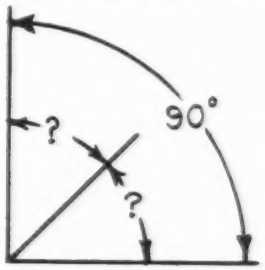
(REMEMBER: IF THE NUMBER INSIDE THE DIVISION BAR IS SMALLER THAN THE NUMBER OUTSIDE, ADD A DECIMAL AND AS MANY 0'S AS YOU NEED.)

PROBLEMS

1. Suppose you have a square that measures 6 inches on each side.
   a. To make the square 1/3 larger, how much longer would each side need to be? (Hint: divide by 3.)

   b. To make the square 1/16 larger, how much longer would each side need to be? (Hint: divide by 16, you may need to add decimals.)

2. If you have a 90^0 angle and you bisect it (divide it in half), what is the measure of the two new angles?



3. How many 1/4 inch blocks can be drawn consecutively (one beside the next) on a line 5 3/16 inches long?

SOLUTIONS

1. a. $3\overline{)6}$ → $\begin{array}{r} 2 \\ 3\overline{)6} \\ \underline{6} \\ 0 \end{array}$

2 inches longer

b. $16\overline{)6.000}$ → $\begin{array}{r} .375 \\ 16\overline{)6.000} \\ \underline{48} \\ 120 \\ \underline{112} \\ 80 \\ \underline{80} \\ 00 \end{array}$

.375 inch longer

2. $2\overline{)90}$ → $\begin{array}{r} 45 \\ 2\overline{)90} \\ \underline{8} \\ 10 \\ \underline{10} \\ 0 \end{array}$

each new angle will be 45^0

3. 5 3/16 ÷ 1/4 =
   83/16 ÷ 1/4 =
   83/16 ÷ 4/1 =
   332/16=
   20 12/16=
   20 3/4 blocks

4. How many triangles with bases of .25 inch can be drawn side by side on a sheet of paper 8.5 inches wide with a .5 inch margin on the left and a .25 inch margin on the right?

5. How many 1/8 inch spaced guidelines can be drawn horizontally on an 8 1/2 inches wide X 11 inches long piece of paper with a 1/2 inch margin on the top and bottom?

6. To find the area of a triangle we multiply the length of the base and the height of the triangle and divide by 2.

$$A = \frac{b \times h}{2}$$

If we know the base of a triangle is 5 inches and the height is 12 inches, what is the area?

4. .5
+.25
.75 inch total margin

8.50 inches paper
− .75 inch total margin
7.75 inches left to use

```
      31
.25  7.75
      75
      25
      25
       0
```

31 triangles

5. 1/2 + 1/2 =
2/2 =
1 inch total margin

11 inches wide paper
− 1 inch total margin
10 inches left to draw on

6. $A = \frac{b \times h}{2}$

$A = \frac{5 \times 12}{2}$

$A = \frac{60}{2}$

$A = 30$

30 inches

10 ÷ 1/8 =
10/1 ÷ 1/8 =
10/1 X 8/1 =
80/1 =
80

80 lines can be drawn

MORE PRACTICE

If you had trouble with the above problems, work the following for additional practice.

1. $180\overline{)360}$

2. $60\overline{)180}$

3. $3/8 \div 1/2 =$

4. $3\ 3/8 \div 1\ 1/2 =$

5. $2.5\overline{)3.75}$

6. $9/32 \div 3/4 =$

7. $3\ 9/16 \div 2\ 3/8 =$

8. $12.25\overline{)441}$

9. $60\overline{)360}$

10. $4\overline{)180}$

SOLUTIONS TO "MORE PRACTICE"

1. $180 \overline{)360}$ = 2

2. $60 \overline{)180}$ = 3

3. $3/8 \div 1/2 =$
   $3/8 \times 2/1 =$
   $6/8 =$
   $3/4$

4. $3\ 3/8 \div 1\ 1/2 =$
   $27/8 \div 3/2 =$
   $27/8 \times 2/3 =$
   $54/24 =$
   $2\ 6/24 =$
   $2\ 1/4$

5. $2.5 \overline{)3.75}$ = 1.5

6. $9/32 \div 4/3 =$
   $9/32 \times 3/4 =$
   $36/96 =$
   $3/8$

7. $3\ 9/16 \div 2\ 3/8 =$
   $57/16 \div 19/8 =$
   $57/16 \times 8/19 =$
   $456/304 =$
   $1\ 152/304 =$
   $1\ 1/2$

8. $12.25 \overline{)441.00}$ = 36.

9. $60 \overline{)360}$ = 6

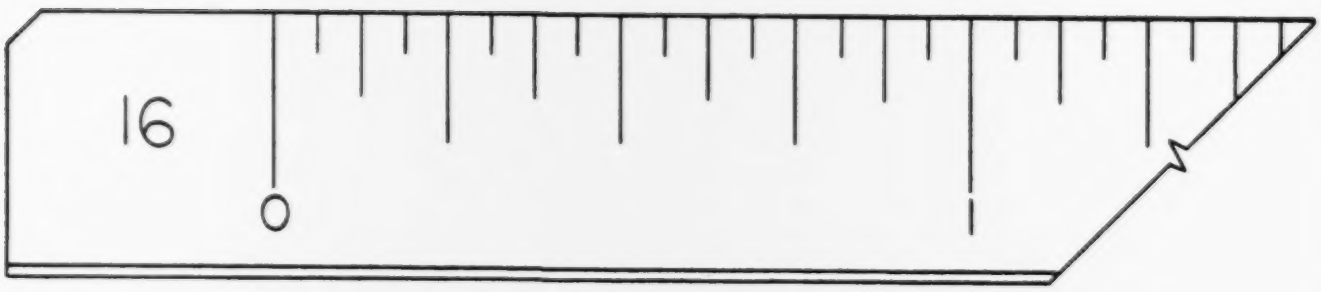
10. $4 \overline{)180}$ = 45

MODULE 2

SCALED MEASUREMENT

Using a scale to measure is very important to drafters. They must be able to accurately read fractions off a scale and also read the measurements from a drawing.

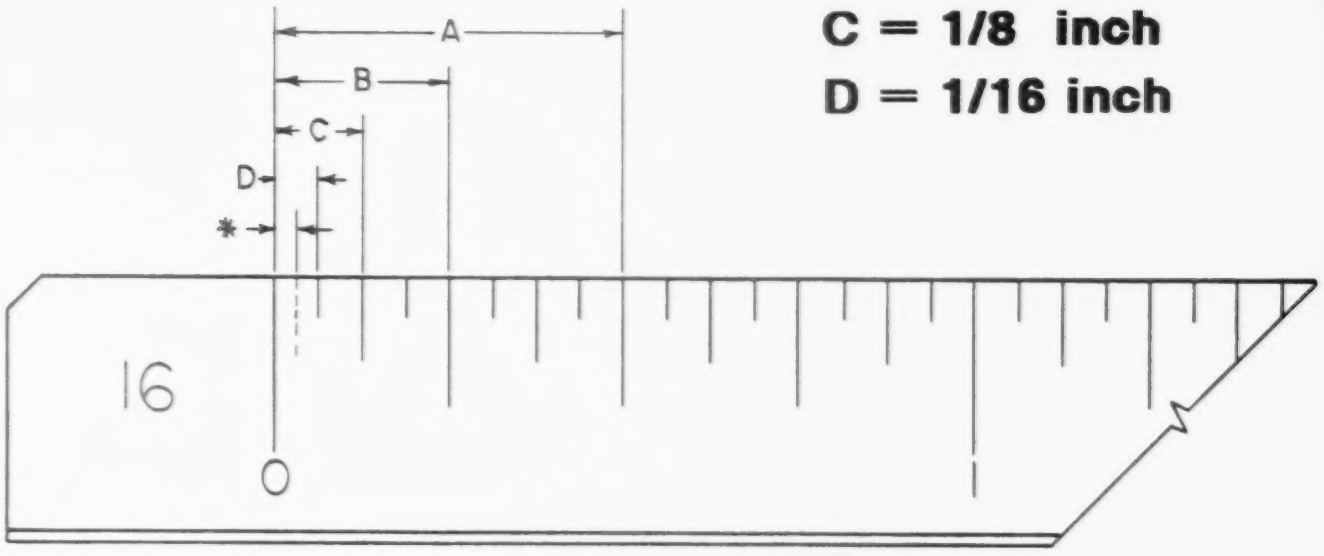
Complete the following module to improve your measuring skills.



THE SCALE

Shown below is an enlarged scale of 1 inch divided into 16 equal parts. The divisions are normally read as follows:

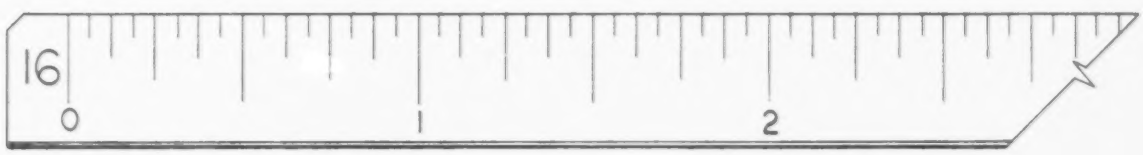
A = 1/2 inch
B = 1/4 inch
C = 1/8 inch
D = 1/16 inch



**NOTE: This value is frequently used and equals 1/32 but does not show up on the scale.*

ALL DIMENSIONS IN THIS UNIT ARE IN INCHES

The scale below can be cut out with scissors. It will be needed for some problems in this module.

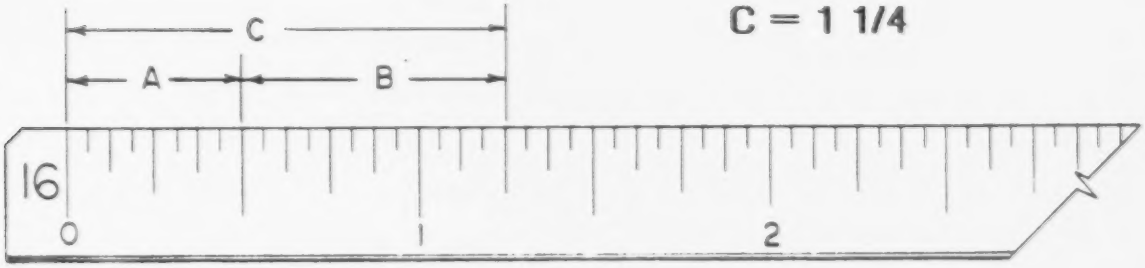


READING THE SCALE

Scales are used by drafters to make measurements. It is very important that each measurement is made accurately or the drawing made using the measurements will be wrong. The following problems will give you some practice reading the scale and using the dimensions.

EXAMPLE:

A = 1/2
B = 3/4
C = 1 1/4



By adding dimension A to dimension B you can find dimension C.

A + B = C
1/2 + 3/4 =
2/4 + 3/4 =
5/4 =
1 1/4
C = 1 1/4

By subtracting dimension A from dimension C you can find dimension B.

C − A = B
1 1/4 − 1/2 =
5/4 − 2/4 =
3/4
B = 3/4

PROBLEMS

1. a. Write the correct value for dimensions A, B and C.

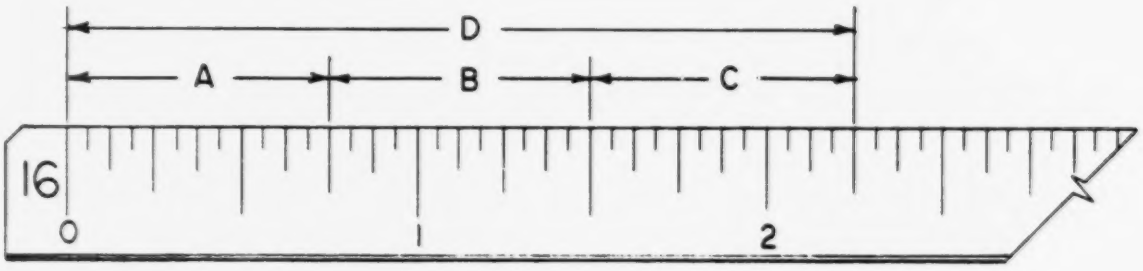
   a. A = _____
   B = _____
   C = _____

   b. Find dimension D by adding A, B and C.

   b. D = _____

   c. Subtract dimension C from dimension D.

   c. _____



2. a. Write the correct values for dimensions A, B, C and D.

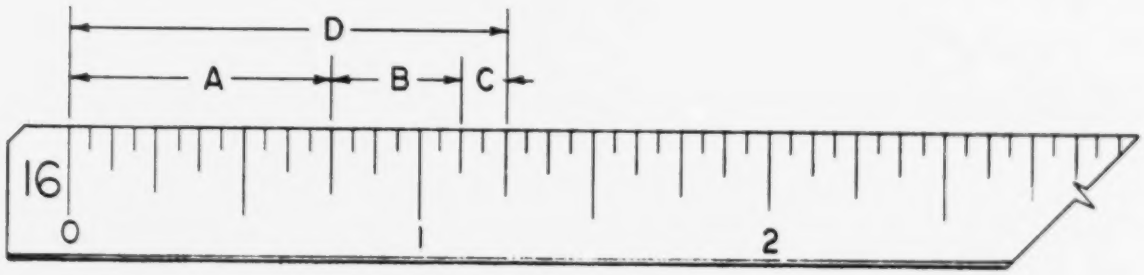
   a. A = _____
   B = _____
   C = _____
   D = _____

   b. Add dimension A to dimension C.

   b. _____

   c. Subtract dimension A from dimension D.

   c. _____



SOLUTIONS

1. a. A = 3/4
   B = 3/4
   C = 3/4

   b. D = 2 1/4

   c. 2 1/4 − 3/4 =
   1 5/4 − 3/4 =
   1 2/4 =
   1 1/2

2. a. A = 3/4
   B = 3/8
   C = 1/8
   D = 1 1/4

   b. 3/4 + 1/8 =
   6/8 + 1/8 =
   7/8

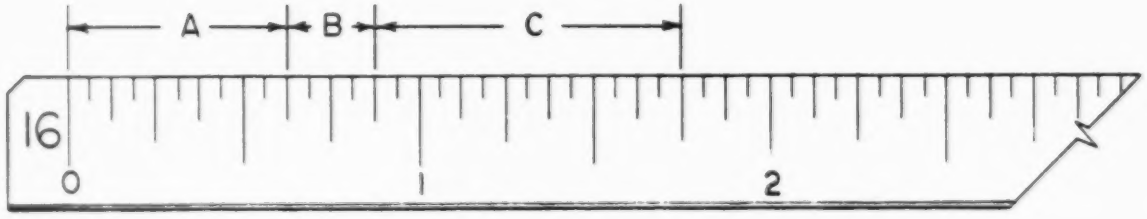
   c. 1 1/4 − 3/4 =
   5/4 − 3/4 =
   2/4 =
   1/2

3. a. Write the correct value for dimensions A, B and C.

a. A = _____
B = _____
C = _____

b. Add dimensions A, B and C. b._____

c. Subtract dimension A from dimension C. c._____

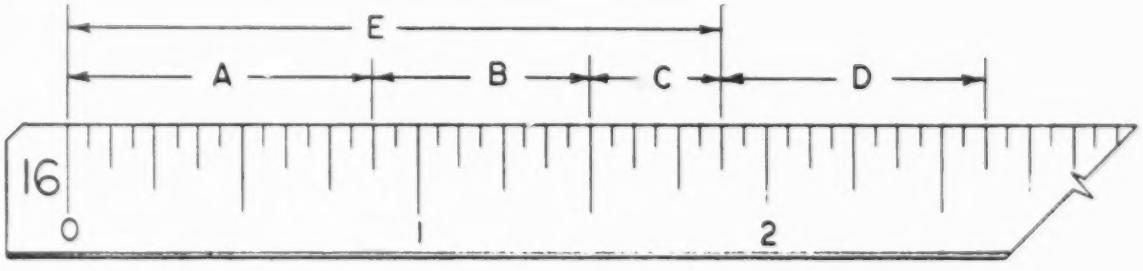


4. a. Write the correct values for dimensions A, B, C, D and E.

a. A = _____
B = _____
C = _____
D = _____
E = _____

b. Add dimension E to dimension D. b._____

c. Subtract dimension C from dimension E. c._____



3. a. A = 5/8
B = 2/8 or 1/4
C = 7/8

b. 5/8 + 1/4 + 7/8 =
5/8 + 2/8 + 7/8 =
14/8 =
1 6/8 =
1 3/4

c. 7/8 − 5/8 =
2/8 =
1/4

4. a. A = 7/8
B = 5/8
C = 3/8
D = 6/8 or 3/4
E = 1 7/8

b. 6/8 + 1 7/8 =
1 13/8 =
2 5/8

c. 1 7/8 − 3/8 =
1 4/8 =
1 1/2

5. a. Write the correct values for dimensions A, B and C.

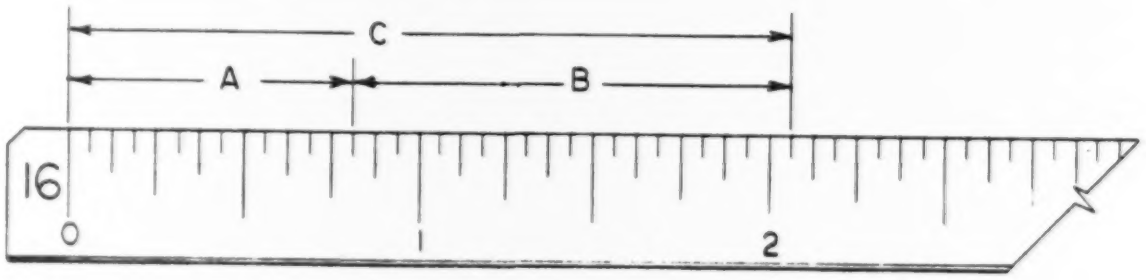
a. A = _____
B = _____
C = _____

b. Add dimension A to dimension C.

b. _____

c. Subtract dimension A from dimension B.

c. _____



6. a. Write the correct values for dimensions A, B and C.

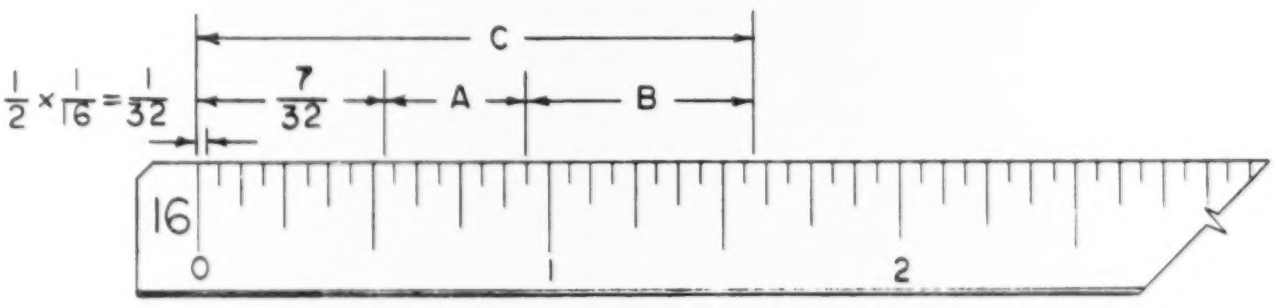
a. A = _____
B = _____
C = _____

b. Add dimension A to dimension B.

b. _____

c. Subtract dimension A from dimension C.

c. _____



5. a. A = 13/16
   B = 1 4/16 or 1 1/4
   C = 2 1/16

   b. 13/16 + 2 1/16 =
   20/16 − 13/16 =
   7/16

   c. 1 4/16 − 13/16 =
   20/16 − 13/16 =
   7/16

6. a. A = 14/32 or 7/16
   B = 20/32 or 10/16 or 5/8
   C = 1 19/32

   b. 14/32 + 20/32 =
   34/32 =
   1 2/32 =
   1 1/16

   or

   7/16 + 10/16 =
   17/16 =
   1 1/16

   c. 1 19/32 − 14/32 =
   1 5/32

READING MEASUREMENTS FROM DRAWINGS

Mechanical drawings prepared by drafters, engineers, architects and designers must be measured, drawn and dimensioned correctly. It is very important that every drafter (including computer aided drafters of the future) be able to work easily with fractions. The following problems are designed to give you some practice with fractions on mechanical drawings.

EXAMPLE: FIND DIMENSION X.

The total length of the sheet metal stamp is 7 1/2 inches. Five different dimensions are needed to determine the total length, four are given. By adding the four that are given and subtracting the sum from the total length, the remaining dimension "X" can be found.

$2 + 1\ 1/4 + 1 + 1\ 1/4 =$

$5\ 2/4 =$

$5\ 1/2$

or

$2 + 1\ 1/4 + 1 + 1\ 1/4 + X = 7\ 1/2$

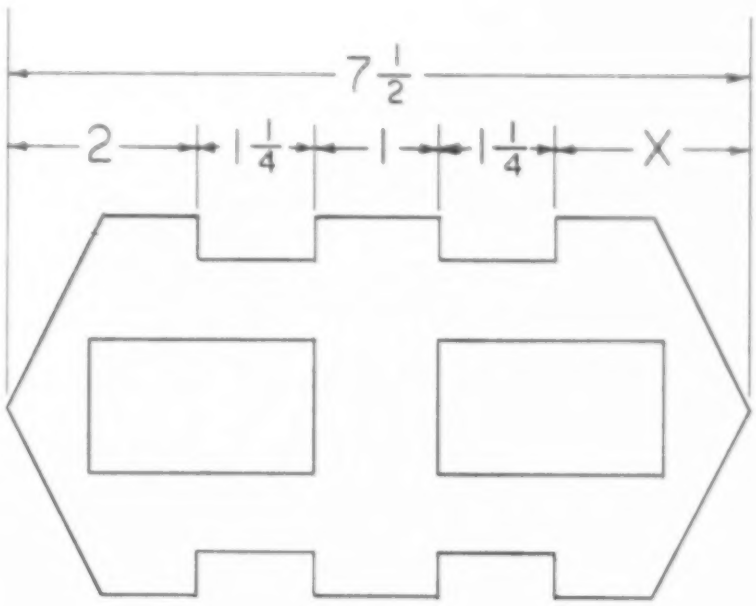
$5\ 1/2 + X = 7\ 1/2$

$-5\ 1/2 \qquad -5\ 1/2$

$X = 2$

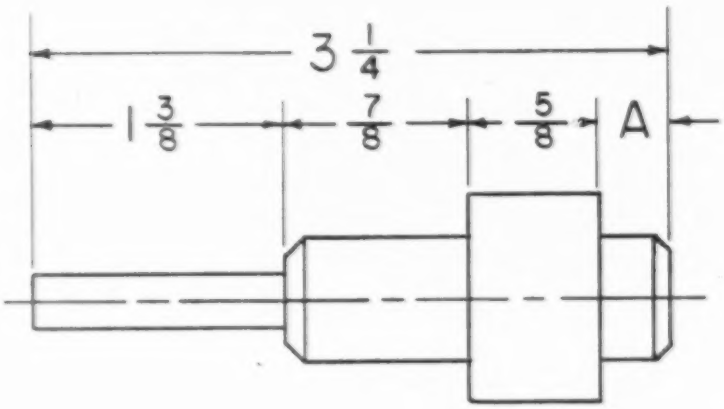
$7\ 1/2 - 5\ 1/2 = 2$

$X = 2$

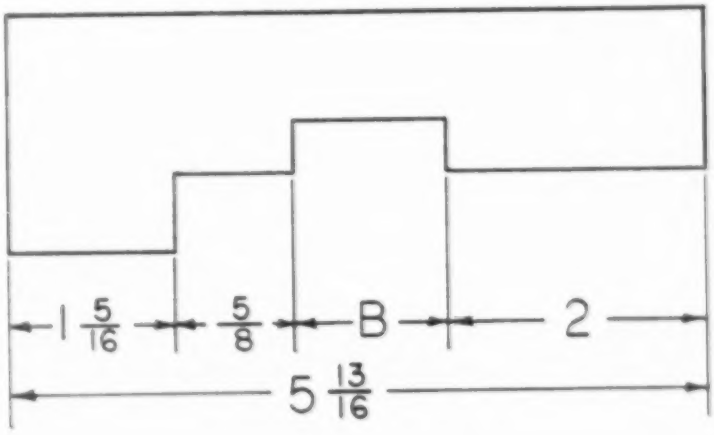


PROBLEMS

1. Solve for the missing dimension A on the shaft. A = _____



2. Solve for dimension B on the following drawing. B = _____



SOLUTIONS

1. 1 3/8 + 7/8 + 5/8 =
   1 15/8 =
   2 7/8

   3 1/4 − 2 7/8 =
   3 2/8 − 2 7/8 =
   2 10/8 − 2 7/8 =
   3/8

   A = 3/8

or

1 3/8 + 7/8 + 5/8 + A = 3 1/4
2 7/8 + A = 3 1/4
− 2 7/8 − 2 7/8
A = 3/8

2. 1 5/16 + 5/8 + 2 =
   1 5/16 + 10/16 + 2 =
   3 15/16

   5 13/16 − 3 15/16 =
   4 29/16 − 3 15/16 =
   1 14/16 =
   1 7/8

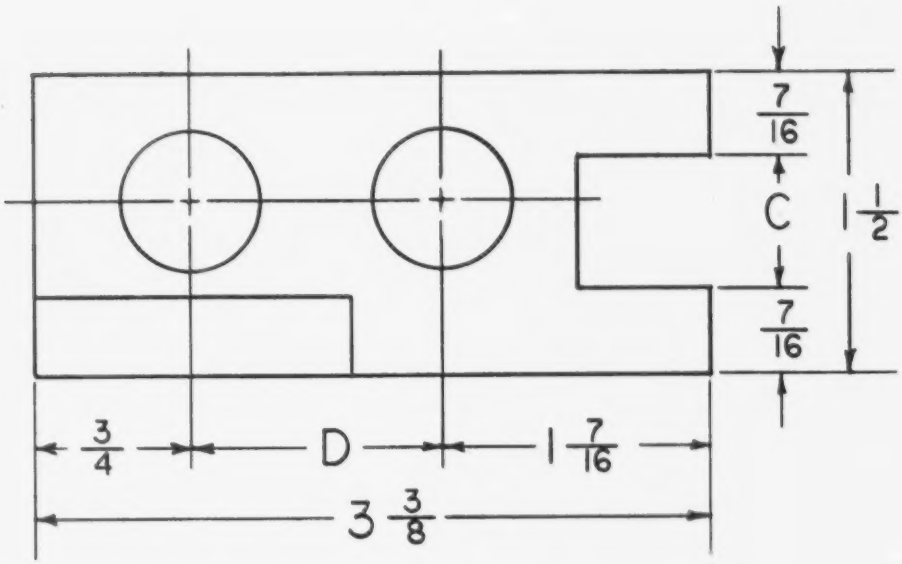
or

1 5/16 + 5/8 + B + 2 = 5 13/16
3 15/16 + B = 5 13/16
− 3 15/16 − 3 15/16
B = 1 7/8

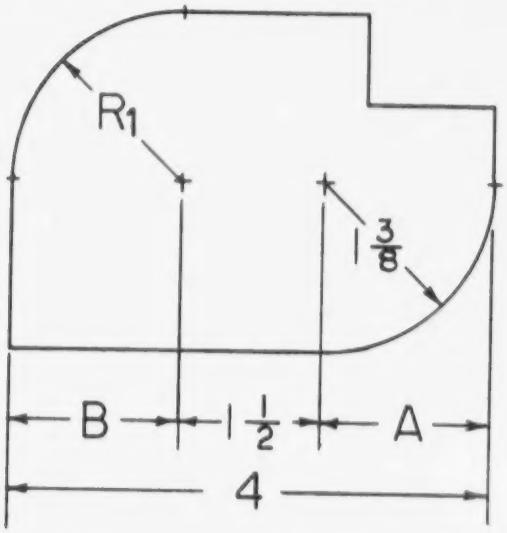
3. Solve for C and D on the following drawing.

C = _____

D = _____



4. Solve for the missing Radius R_1 on the stamped part. R_1 = _____



Given : A = 1 3/8 and B = R_1

NOTE: Dimensions shown at A and B are not normally placed on a drawing.

3. C =

7/16 + 7/16 =

14/16 =

7/8

or

7/16 + C + 7/16 = 1 1/2

7/8 + C = 1 1/2

− 7/8 − 7/8

C = 5/8

1 1/2 − 7/8 =

1 4/8 − 7/8 =

12/8 − 7/8 =

5/8

C = 5/8

D =

3/4 + 1 7/16 =

12/16 + 1 7/16 =

1 19/16

2 3/16

or

3/4 + D + 1 7/16 = 3 3/8

2 3/16 + D = 3 3/8

− 2 3/16 − 1 3/16

D = 1 3/16

3 3/8 − 2 3/16 =

3 6/16 − 2 3/16 =

1 3/16

D = 1 3/16

4. 1 1/2 + 1 3/8 =

1 4/8 + 1 3/8 =

2 7/8 =

or

B + 1 1/2 + 1 3/8 = 4

B + 2 7/8 = 4

− 2 7/8 − 2 7/8

B = 1 1/8

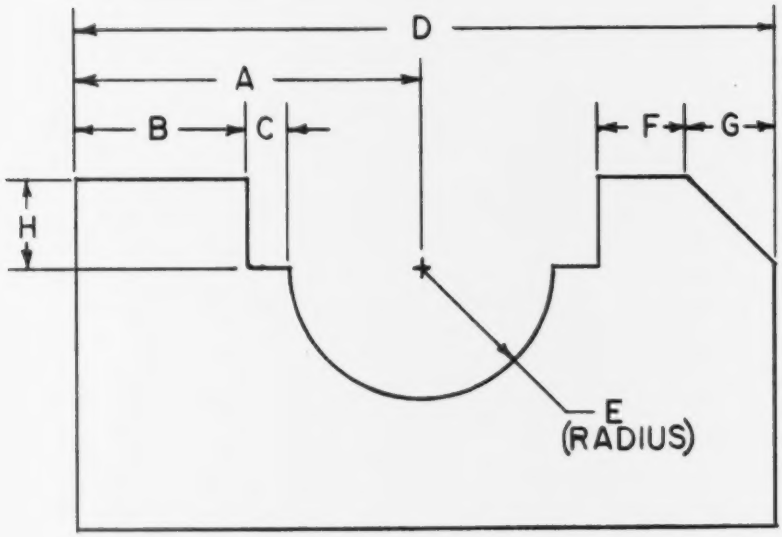
4 − 2 7/8 =

3 8/8 − 2 7/8 =

1 1/8

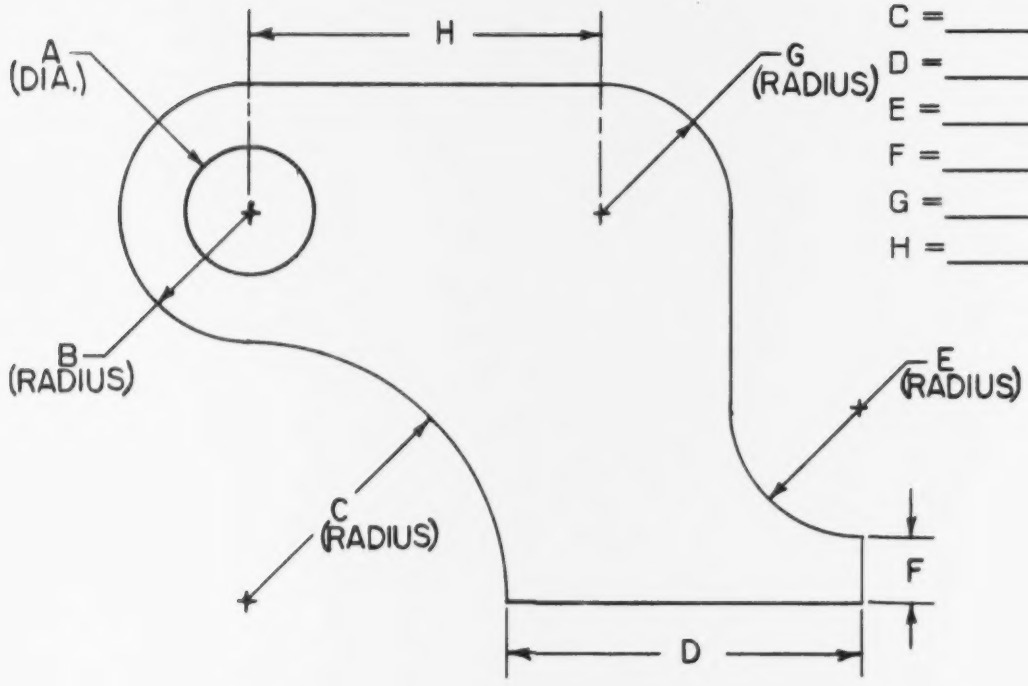
USING THE "CUT OUT" SCALE FURNISHED AT THE BEGINNING OF THIS MODULE, MEASURE AND RECORD THE FOLLOWING.

5.



A = _____
B = _____
C = _____
D = _____
E = _____
F = _____
G = _____
H = _____

6.



A = _____
B = _____
C = _____
D = _____
E = _____
F = _____
G = _____
H = _____

MODULE 3

BASIC MATHEMATICS, SCALE AND GEOMETRY APPLIED TO DRAFTING AND TECHNICAL DRAWING

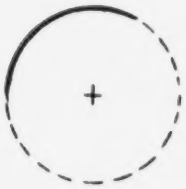
INTRODUCTION

Every item we encounter is composed of geometric shapes. Every drawing a drafter does utilizes one or more geometrical shapes drawn to scale such as squares, rectangles, triangles, circles and arcs. This module is designed to help you understand scale reading and geometric concepts as they are used by drafters.

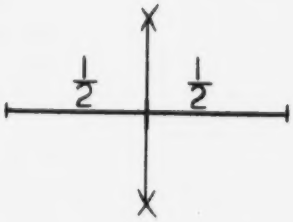
A glossary of terms is also included.

GLOSSARY OF DRAFTING TERMS

ARC — A part of a circle

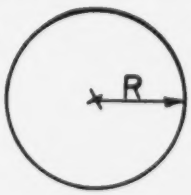


BISECT — To divide in half

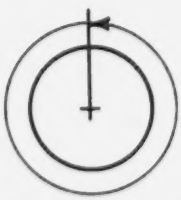


CHORD —A line segment with endpoints on a circle

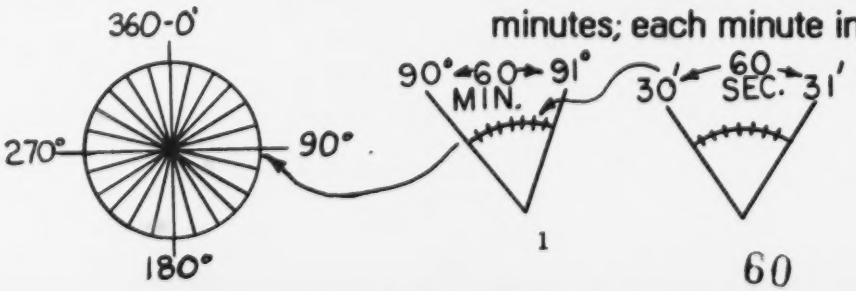
CIRCLE — A round complete loop that is the same distance from the center point to all points along the loop



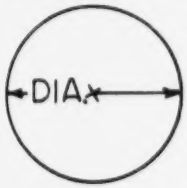
CIRCUMFERENCE — Distance around a circle



DEGREE/MINUTE/SECOND — Measurement increments for angles. Each degree can be divided into 60 minutes; each minute into 60 seconds



DIAMETER – Distance from edge to edge through the center of a circle



ELLIPSE – A circle seen at an angle

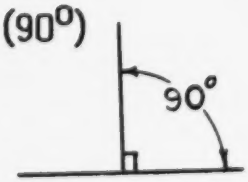
HEXAGON – A polygon of 6 sides

OCTAGON – A polygon of 8 sides

PARALLEL – Two lines that could never meet even if extended to infinity and with the distance between the two always remaining the same

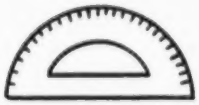
PERIMETER – Total distance around a polygon

PERPENDICULAR – Lines, rays or segments at right angles (90^{o})

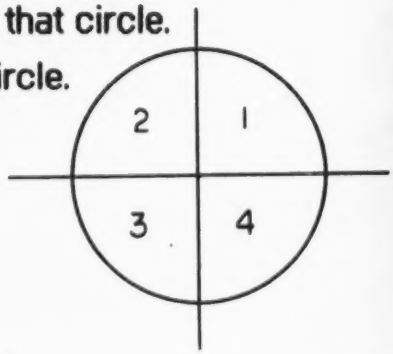


POLYGON – A shape with 3 or more sides

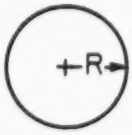
PROTRACTOR — Instrument for measuring angles



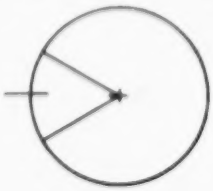
QUADRANT — A certain area of a circle. Each section, or quadrant, is 1/4 of the circle and contains 90^{o} of that circle. There is a total of 4 quadrants to any circle.



RADIUS — Distance from center of circle to edge



SECTOR — Part of a circle bounded by any two radii and the included arc

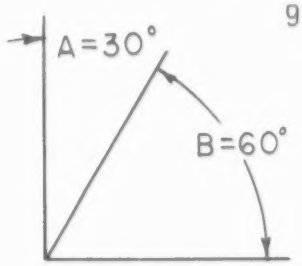


TANGENT — A line, or arc, touching another arc or circle at only one point

TRIANGLE — Shape with 3 sides

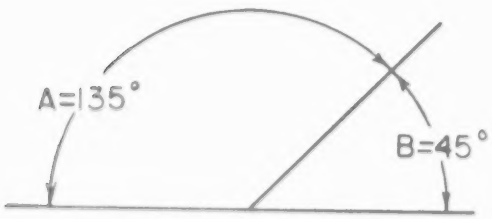
ANGLE RELATIONSHIPS CONTAINED WITHIN ONE QUADRANT

Complementary angles – the sum of two angles, normally adjacent, that equals 90^0



$A + B = 90^0$

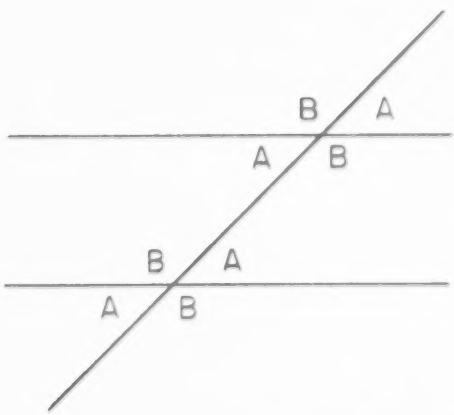
Supplementary angles – the sum of two adjacent angles that equals 180^0

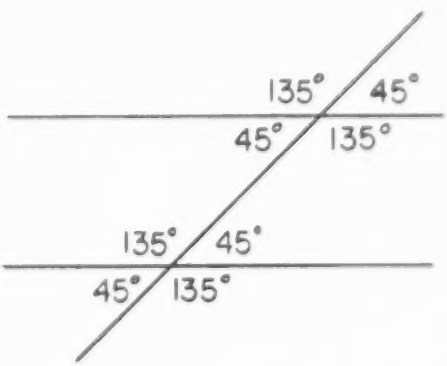


$A + B = 180^0$

A line passing through two parallel lines will create angles of equal measure at several places.

EXAMPLE





The sum of the interior angles of a convex polygon can be found with the following formula:

$$180\ (n - 2) = s$$

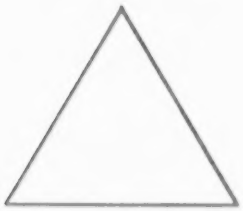
("n" is the number of sides a polygon has)

EXAMPLE:

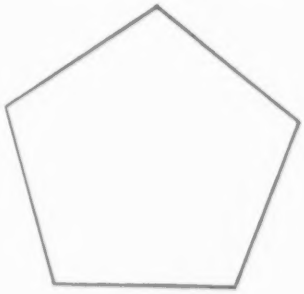
$S = 180\ (N-2)$
$= 180\ (3-2)$
$= 180\ (1)$
$= 180^0$

$S = 180\ (N-2)$
$= 180\ (5-2)$
$= 180\ (3)$
$= 540^0$

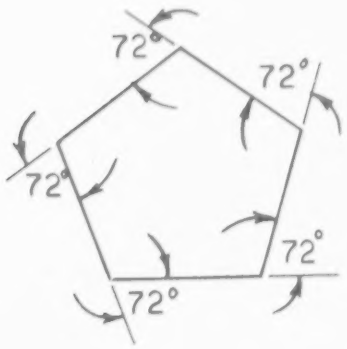
3 INTERIOR ANGLES



5 INTERIOR ANGLES



The sum of the exterior angles of a polygon formed by extending the sides as shown is always 360^0 (no matter how many sides).



$5 \times 72^0 = 360^0$

PROBLEMS

1. Find lettered angles

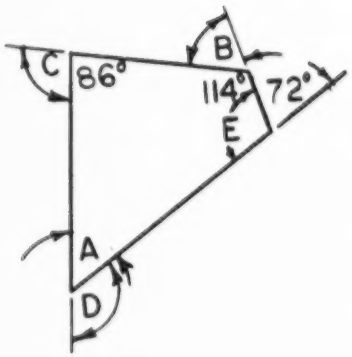
A = ____

B = ____

C = ____

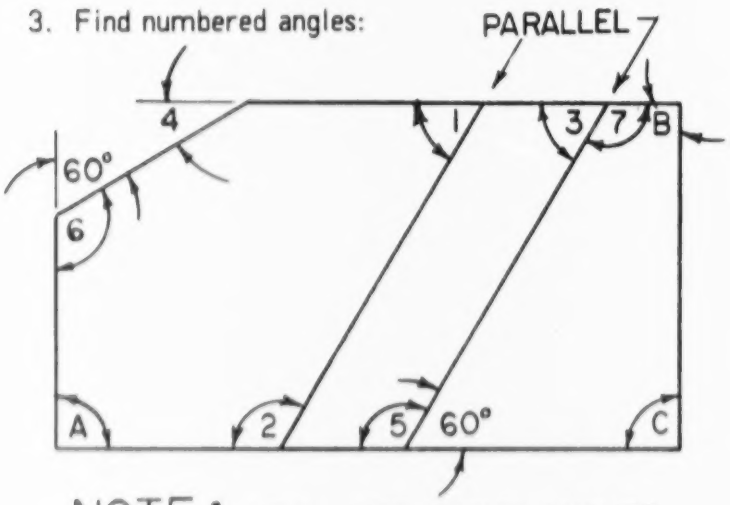
D = ____

E = ____



2. What is the sum of angles B, C, D, and E? ____

3. Find numbered angles:



NOTE: A,B,C, ARE RIGHT ANGLES

1 = ____

2 = ____

3 = ____

4 = ____

5 = ____

6 = ____

7 = ____

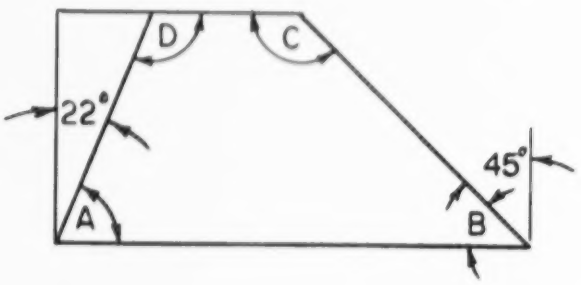
4. Find the lettered angles (Assume overall shape is a rectangle):

A = ____

B = ____

C = ____

D = ____



SOLUTIONS

1. A = The sum of the interior angles is determined using $s = 180\ (n-2)$ therefore the sum of the angles in this problem is 360^0. We know the sum of the three angles given is 272^0. If we subtract 272 from 360 we find that the measure of the 4th angle is 88^0.

$$B = 180^0 - 114^0 = 66^0$$

$$C = 180^0 - 86^0 = 94^0$$

$$D = 180^0 - 88^0 = 92^0$$

$$E = 180^0 - 72^0 = 108^0$$

2. 360^0

3. 1. 60^0
   2. 120^0
   3. 60^0
   4. 30^0
   5. 120^0
   6. 120^0
   7. 120^0

4. A. $90^0 - 22^0 = 68^0$

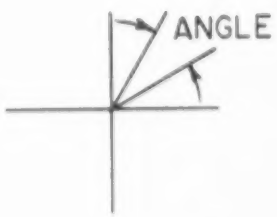
   B. $90^0 - 45^0 = 45^0$

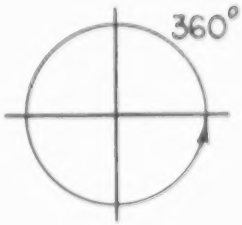
   C. 135^0

   D. $180^0 - 68^0 = 112^0$

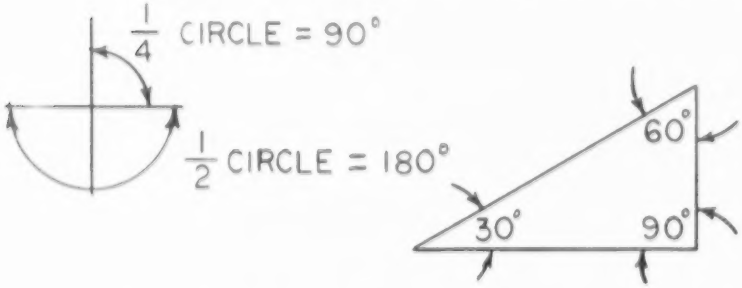
MEASURING ANGLES

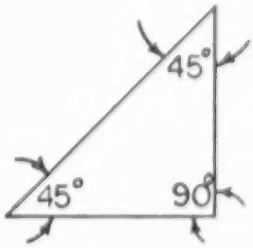
There are 360 degrees or tiny "pie segments" in a circle.





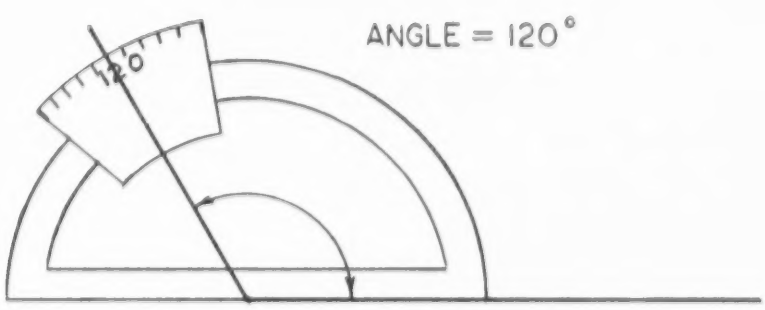
Some angles are used so much that we need to know their shapes:





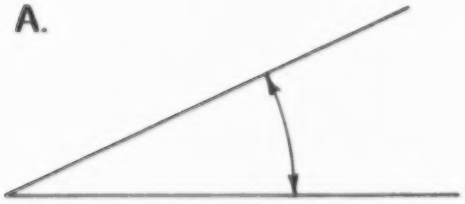
Angles are measured with a protractor. Usually, protractors are half circles marked in increments from 0^0 to 180^0 in both directions. To measure an angle, place the center mark of the protractor at the vertex of the angle with the 0^0 line of the protractor along the base leg of the angle. Read the degree mark closest to the other leg of the angle.

EXAMPLE:

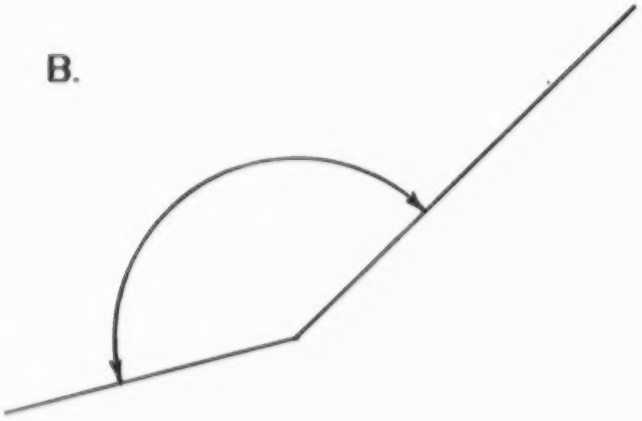


PROBLEMS: MEASURE THESE ANGLES

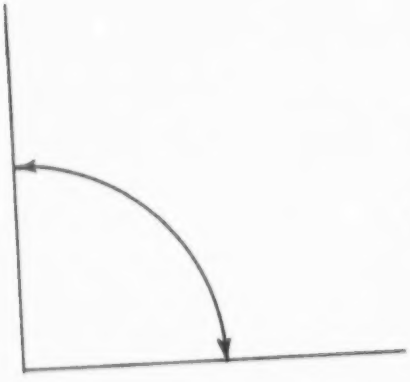
A.



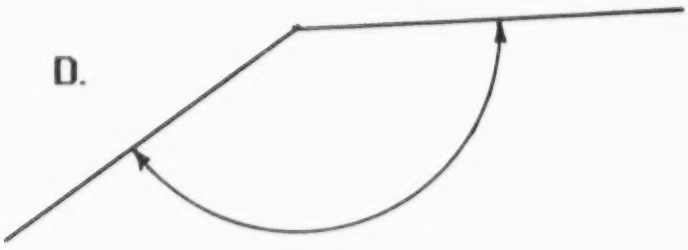
B.



C.



D.



SOLUTIONS

A. 25°

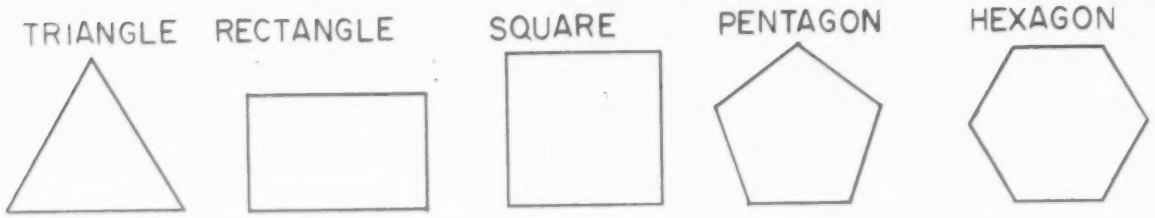
B. 145°

C. 90°

D. 150°

POLYGONS

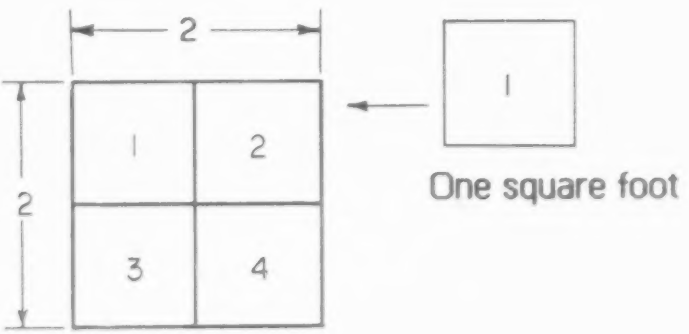
A polygon is any shape with three or more straight sides. Some common polygon shapes with which you should be familiar are as follows:



AREAS OF POLYGONS

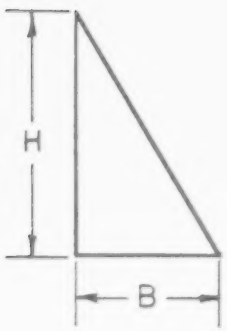
SQUARES AND RECTANGLES – Areas are always in square units. The area of a square if found by multiplying one side by another.

$A = b \times h$
$= 2 \times 2$
$= 4$ sq. ft.

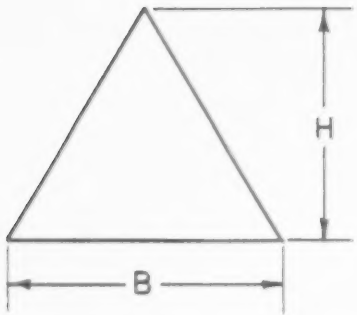


Triangle

$A = \frac{b \times h}{2}$



or

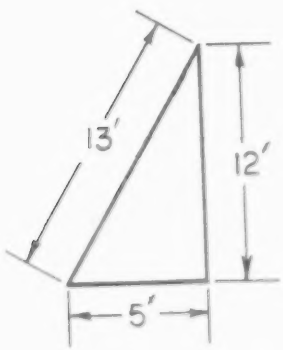


Example:

$A = \frac{b \times h}{2}$

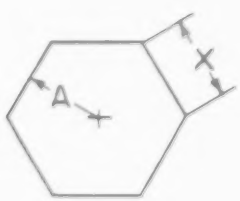
$= \frac{5 \times 12}{2}$

$= 30$ sq. ft.



Pentagon, hexagon, octagon, or any regular polygon
(A regular polygon has all sides equal)

$A = \frac{1}{2} \times a \times p$ Where P = the perimeter (or 6X)

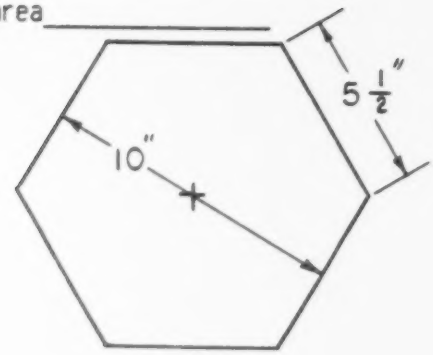


PROBLEMS

Name these shapes and figure their areas

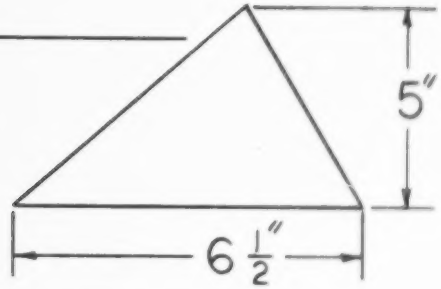
1. shape_____

area_____



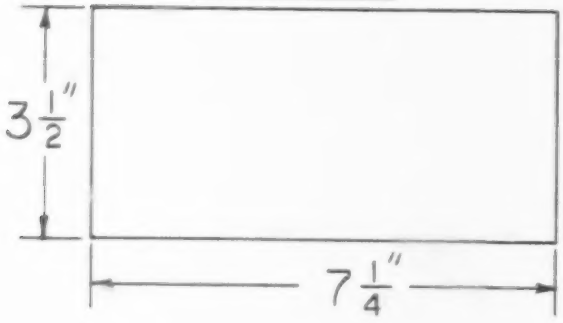
2. shape_____

area_____



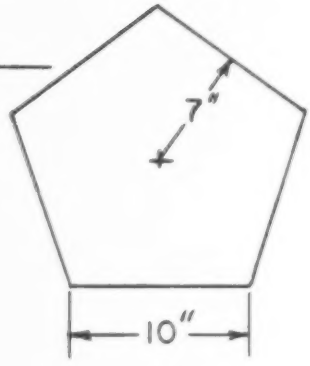
3. shape_____

area_____



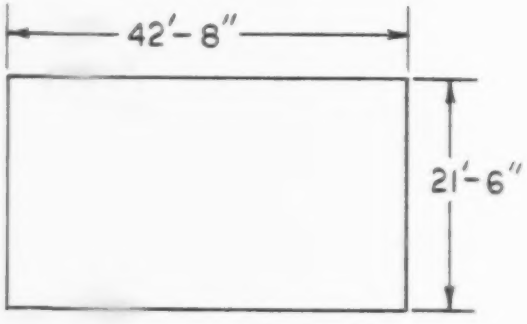
4. shape_____

area_____



5. shape_____

area_____



SOLUTIONS

1. Shape = Hexagon
   Area = A = 1/2 X 5 X 33
   P = 6 X 5 1/2
   P = 6 X 5.5
   P = 33
   A = .5 X 5 X 33
   A = 2.5 X 33
   A = 82.5 square inches

2. Shape = Triangle
   Area = $A = \frac{b \times h}{2}$
   $A = \frac{6\ 1/2 \times 5}{2}$
   $A = \frac{6.5 \times 5}{2}$
   $A = \frac{32.5}{2}$
   A = 16.25 square inches

3. Shape = Rectangle
   Area = A = bxh
   A = 7 1/2 X 3 1/2
   A = 7.5 X 3.5
   A = 25.375 square inches

4. Shape = Pentagon
   Area = A = 1/2 X a X p
   P = 5 X 10
   P = 50
   A = .5 X 7 X 50
   A = 3.5 X 50
   A = 175 square inches

5. Shape = Rectangle
   Area = A = bxh
   A = 42 ft. 8 in. X 21 ft. 6 in. must convert to inches
   42 ft. = (12 X 42) = 504 in.
   504 in + 8 in = 512 in

   21 ft. = (12 X 21) = 252 in.
   252 in. + 6 in. = 258 in.

therefore:
A = 512 X 258
A = 132096 square inches convert back to square feet by dividing by 144.
132096 ÷ 144 = 917.33 square feet

Note: 1 square foot = 144 square inches